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Dilatancy and shear thickening of particle suspensions

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Shear thickening is a fascinating subject, as 99.9% of complex fluids are thinning; thickening systems thus are the "exception to the rule" that needs to be understood. Moreover, such tunable systems show very promising applications, e.g. to block large underground pores in oil recovery to maintain a constant oil flow by plugging water filled pores (an approach used in oil recovery by e.g. Shell), or to manufacture bulletproof vests that are comfortable to wear, but stop bullets nonetheless. We study the rheology of non-Brownian particle suspensions (notably, cornstarch) that exhibit shear thickening. Using magnetic resonance imaging (MRI), the local properties of the flow are obtained by the determination of local velocity profiles and concentrations in a Couette cell. We also perform macroscopic rheology experiments in different geometries. The results suggest that the shear thickening is a consequence of dilatancy: the system under flow attempts to dilate but instead undergoes a jamming transition, because it is confined. This proposition is confirmed by an independent measurement of the dilation of the suspension as a function of the shear rate.